(12) UK Patent Application (19) GB (11) 2 140 026 A

(43) Application published 21 Nov 1984

(21) Application No 8410904

(22) Date of filing 27 Apr 1984

(30) Priority data
(31) 494626 (32) 16 May 1983 (33) US

(51) INT CL³
C10J 3/20

(52) Domestic classification
C5E AF

(56) Documents cited
None

(58) Field of search
C5E

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(54) Improvements in or relating to a fixed bed gasifier

(57) A fixed bed gasifier and method of gasification of solid carbonaceous fuel wherein there is provided a fuel supply and inlet means 11 to the gasifier and at least one vertical feed tube 17 in the form of an inverted truncated cone. The feed tube is enclosed in a gaseous exhaust gas conduit 23 and the bulk of gases from the gasifier passes upwardly through descending coal in the feed tube and through apertures 25 in the wall of the feed tube into a chamber 27 formed between the feed tube and exhaust gas conduit while a portion of hot gases from the gasifier passes directly into the chamber 27 to maintain the temperature of the gases when combined in the chamber above their dew point. The combined gases are tangentially discharged from the chamber through a pipe 29 or 29' and, when a plurality of feed tubes are provided, the discharged gases combined and removed through a common offtake conduit 31.

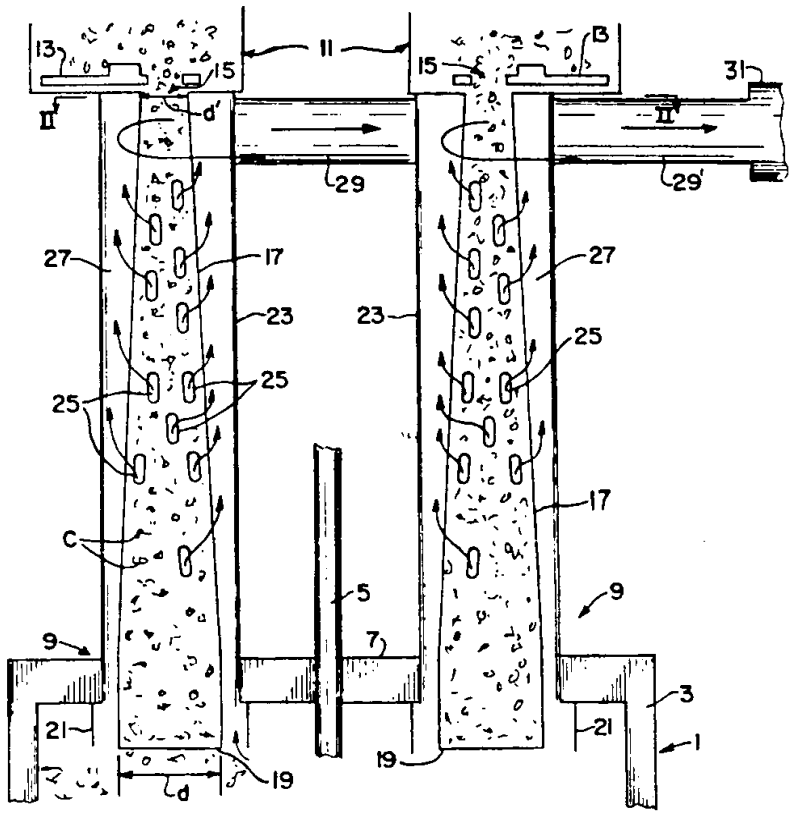

FIG. 1

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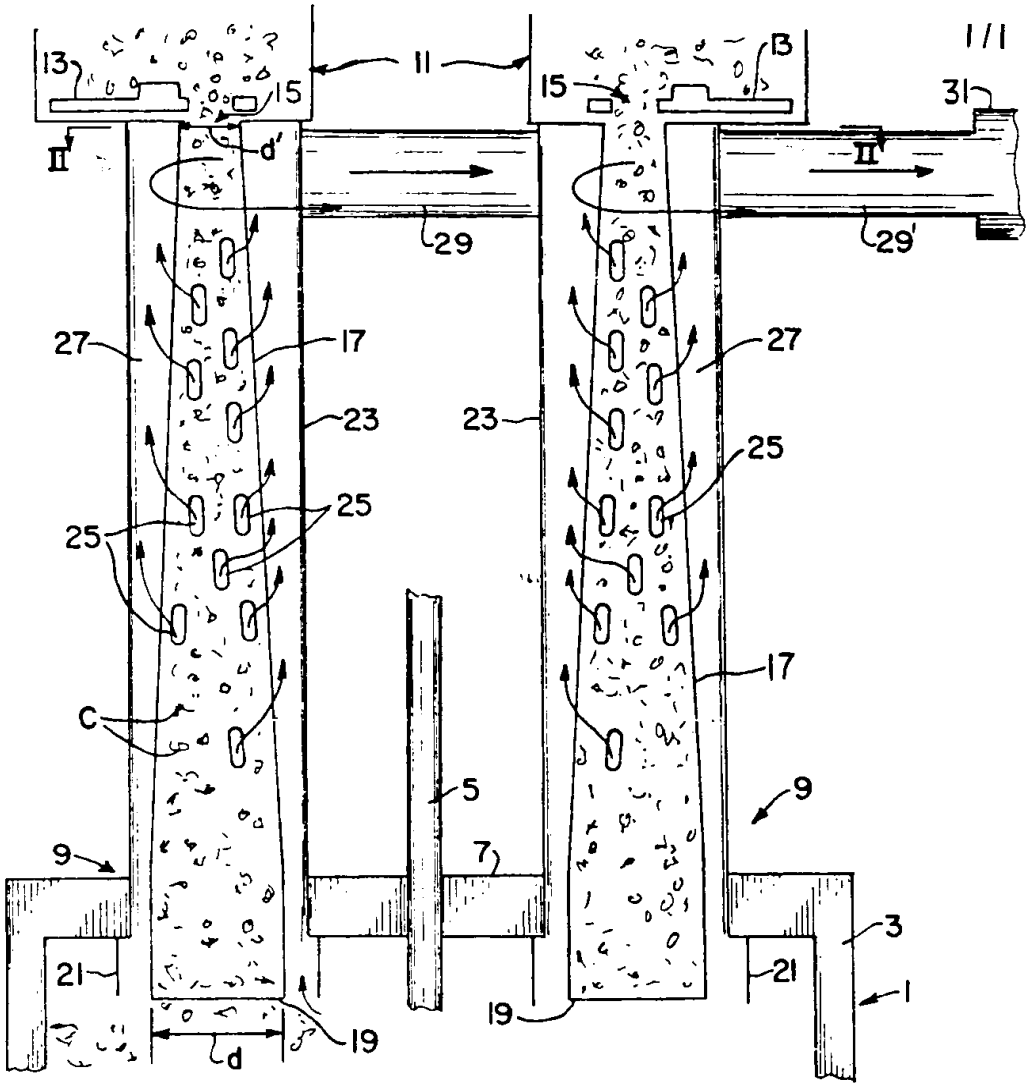
13
11
15
13
15
31
II
d'
II
29
29'
27
17
23
23
27
25
25
25
C
17
5
9
9
7
3
21
21
1
19
19
d

FIG. 1

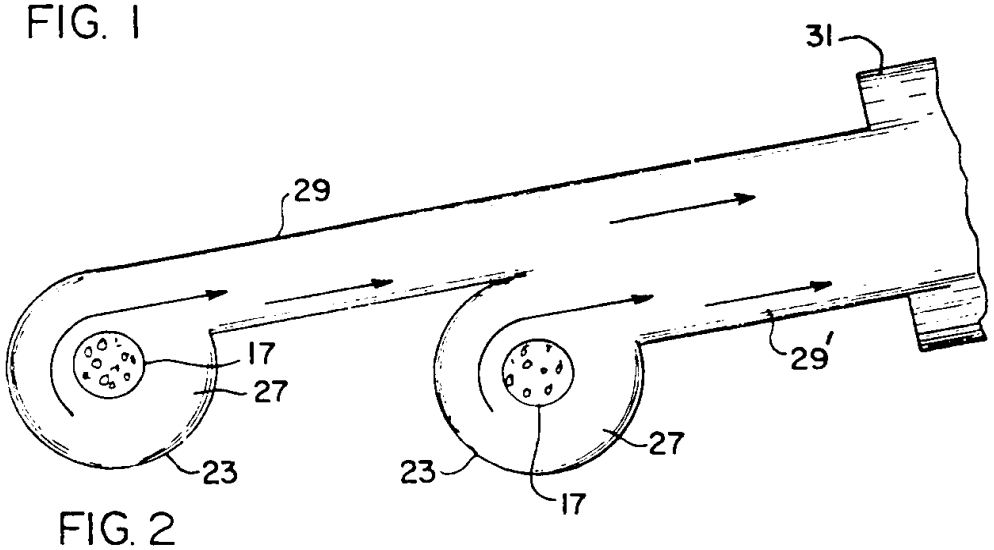
31
29
17
27
23
23
27
17
29'

FIG. 2

SPECIFICATION

Improvements in or relating to a fixed bed gasifier

THIS INVENTION relates to a fixed bed, single stage gasifier. Fixed bed, single stage gasifiers are used to gasify coal or other solid carbonaceous fuel to produce combustible gases. Generally, the gases produced are collected at the top of the gasifier vessel, above the fuel bed, and are exhausted from the vessel through an offtake pipe. The gases are at an elevated temperature and contain particulate matter. If the carbonaceous fuel being gasified is a bituminous coal or any coal of lower rank, the offtake gases may also contain vaporized tars and oils.

In conventional practice, the offtake gases from a fixed bed gasifier are passed through a refractory-lined cyclone which removes a portion of the particulates. In conventional bituminous coal gasification, the gases are then delivered to the burner through the thermally insulated pipe so as to prevent the deposition of tars and oils on the internal surface of the delivery pipe, which would require subsequent removal. If the gases are to be transported for any significant distance, it is customary practice to cool the gases in a scrubber, which causes condensation of the tars and oils within the scrubber thus facilitating their removal from the transported gaseous stream.

In situations where the hot gases containing tars and oils are fed directly to a burner, the construction of refractory-lined distribution piping is expensive, and intermittent operation of the gasifier will still result in the need for frequent cleaning of the gas distribution pipe.

In situations where cooles gas is required, the problem of removing the tars and oils from the scrubbing water requires the use of separation tanks and pumps which are both costly and cumbersome. Also, cooling of the product gases, to remove tars and oils, reduces the efficiency of the gasification process.

In addition, in conventional fixed bed gasifiers the space within the gasifier vessel, at the top of the vessel, which must be provided so as to allow the gases to flow to the offtake pipe, lowers the fuel reaction potential at full load by imposing a limit on the contact time between the gas being produced and the coal entering the gasifier.

Attempts have been made to use the coal in the gasifier for the purpose of removing some of the particulates from the gases. In U.S. 4,165,970, there is disclosed a gasifier for the high pressure gasification of coal, of a particulate size of 2–60 mm. A shielding wall is provided within the gasifier through which coal is fed and the coarser particles are said to accumulate near the shielding wall, while finer particles tend to enrich the central portion of the bed. The shielding wall is separate from the reactor wall and an annular space is formed. The shielding wall has apertures through which gases will pass after flowing through the coal fed to the reactor. The passage of gas through the coal bed having a distribution of the different particle sizes is said to tend to decrease the rate at which dust is entrained by the product gas leaving the reactor. This is due to the gas entering the annular chamber at its lower end as well as entering through the openings in the shielding wall. While some tangential flow of gases toward the discharge from the vessel may result, no specific such tangential flow is discussed. While such an approach may remove some particulates from the gases to be exhausted from the gasifier since the coal acts in the nature of a filter, it does not significantly reduce the amount of vaporized tars and oils present in the gases that are exhausted from the gasifier.

According to one aspect of this invention there is provided a fixed bed, solid carbonaceous fuel gasifier having a combustion chamber, a substantially vertically extending feed member extending from a solid fuel supply means to an inlet means for charging solid carbonaceous fuel to the upper portion of the gasifier, through which solid fuel is charged by gravity to the gasifier; a gaseous exhaust conduit, coaxial with and surrounding the feed member and spaced therefrom, the feed member having a plurality of apertures therethrough for the flow of gases therefrom into the exhaust conduit; the exhaust conduit having means adjacent the upper end thereof for the tangential removal of gases therefrom.

Upon passage of the gases through the descending coal in the feed tubes, the tars and oils are condensed and returned to the gasifier vessel, while the descending coal bed also filters out particulates.

Preferably the dimeter of the feed member increases with increasing distance from the fuel supply means.

Conveniently said vertically extending feed member is in the shape of an inverted truncated cone, which may have an elliptical cross-section shape, or a rectangular cross-sectional shape.

Conveniently said vertically extending feed member terminates within the gasifier vessel and a baffle means is provided in the vessel dependent from the roof thereof spaced from and surrounding the lower end of said feed member.

Preferably the space between the exhaust conduit and the feed member communicates with the combustion chamber.

In a preferred embodiment a plurality of inlet means are present in the gasifier and a substantially vertically extending feed member and gaseous exhaust conduit are provided for each of said inlet means.

Preferably the gases removed tangentially from the upper end of each exhaust conduit are combined and fed to a common exit gas conduit.

According to another aspect of this invention there is provided a method for producing combustible gases in a fixed bed, single stage coal gasifier, the method comprising: passing coal from a source thereof downwardly through a substantially vertically extending feed member positioned above the gasifier, said feed member having apertures therein, the feed member being contained within an exhaust gas conduit forming an annular chamber therewith, the exhaust gas conduit having a tangential exit gas conduit at the upper region thereof and charging the coal through an inlet into the combustion chamber; gasifying the coal to produce combustible gases; passing a portion of the hot gases directly from the gasifier into the annular chamber; passing the remainder of the hot gases from the gasifier upwardly through the descending coal in the feed tube to cool the same and condense tars and oils therein and discharging the cooled gases through the apertures in the feed tube into the chamber to combine with said hot gases; and tangentially discharging the combined hot and cooled gases from the upper region of the chamber into an exit conduit.

Preferably the portion of hot gases passed directly from the gasifier into the annular chamber is sufficient to maintain the temperature of the combined gases above the dew point of the gas.

Conveniently up to ten percent of the gases from the gasifier are passed directly from the gasifier into the annular chamber.

Advantageously said feed member has a larger interior diameter at the lower end thereof than at the upper region thereof, sufficient to permit the passage of swelling and caking coals by gravity downwardly therethrough into the gasifier.

Preferably a plurality of said vertically extending feed members and exhaust gas conduits are provided and gases from the gasifier are passed therethrough and the gases are discharged from the upper regions of the annular chambers into exit conduits to be combined in a common gas offtake conduit.

In order that the invention may be more readily understood, and so that further features thereof may be appreciated, the invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 is a vertical sectional view of the upper section of a fixed bed gasifier of the present invention; and

Figure 2 is a view taken along lines II-II of Fig. 1.

Referring now to the drawings, there is illustrated a fixed bed carbonaceous fuel gas producer vessel 1, having a combustion chamber, the vessel having a jacket 3, and a shaft 5 for an agitator which passes through the roof 7 of the vessel. The roof 7 also has therein a plurality of openings 9 for the introduction of coal to the vessel.

An elevated fuel bin 11 is provided, above the vessel 1 from which coal is to be charged, by gravity, to the vessel, the bin having a valve 13 to control the flow of coal through an opening 15 in the bin.

A feed tube, in the form of an inverted, truncated conical member 17, is connected to the opening 15 of the fuel bin and guides the flow of coal from the bin 11 into the vessel 11, through openings 9, the lower end 19 of the conical member being situated within the vessel 1. The term "conical member," as used herein, is meant to include, in additional to a cone of circular cross-section, a conical member of elliptical or rectangular or any other appropriate cross-sectional shape. A baffle 21 is provided, depending from the roof 7 of the vessel 1 and spaced from the lower end 19 of the conical member 17. The conical member 17 is constructed such that the lower end 19 has a larger interior diameter d than the interior diameter d' of the upper region of the conical member at the opening 15 of the fuel bin.

A conduit 23, which forms a duct for the gaseous exhaust from the vessel 1, is provided which is coaxial with, surrounds, and encloses the conical member 17 while being spaced therefrom. The conduit 23 extends from the roof 7 of the gasifier vessel 1 to the elevated fuel bin 11.

A plurality of slots or apertures 25 are provided in the conical member 17 which provide access between the interior of the conical member 17 and the chamber 27 formed by the conical member and the spaced conduit 23. The apertures 25 are sized and spaced such that gas from the gasifier 1 will flow through the fuel feed and be gradually admitted through apertures 25 into the chamber 27. The apertures are further designed such that most of the gas will flow through most of the fuel flowing into the gasifier 1, that is, most of the gas will exit near the top of the conical member 17.

A tangential exit conduit 29 is connected to and communicates with the conduit 23 (Fig. 2) and this conduit is in turn connected to a similar exit conduit 29′ on an adjacent conduit 23, both of which exit conduits discharge into a gas offtake conduit 31.

In the operation of a fixed bed solid carbonaceous fuel gasifier as described, coal from a fuel bin 11 flows through valve 13, through opening 15, into the upper region of the conical member 17 and at substantially atmospheric pressure moves downwardly by gravity through the opening 9 in the roof 7 of the vessel 1. The larger interior diameter d at the

lower end 19 of the conical member 17, relative to the upper region interior diameter *d'* allows continued flow of coal *c*, despite the swelling or caking which may occur when high swelling butuminous coals are gasified. The baffle 21, extending downwardly into the gasifier vessel 1, allows for a slight space between the underside of the roof 7 and the top of the fuel bed. Gases generated in the combustion chamber flow upwardly through the lower end 19 of the conical member 17 countercurrent to the flow of coal and diffuse into the chamber 27 formed between the conical member 17 and the conduit 23, through apertures 25 in the conical member 17. As the gas flows upwardly through the descending coal, it is cooled by the coal, and tars and oils contained in the hot gas condense and are deposited on the surface of the descending coal. While most of the gas flows through the coal, a small fraction of the hot gas stream flows through the annulus formed by the opening at the bottom of the conical member 17 and the conduit 23. This hotter gas blends, in the chamber 27, with the gases flowing through apertures 25 so as to keep the temperature of the exit gas stream above the dew point of the gas.

The amount of hot gas that is passed through the annulus directly into the bottom of the chamber 23 is determined by the temperatures required to keep the exit gas stream above the dew point. The amount may vary depending upon the type of coal being gasified. Preferably, however, about 90 percent, and up to about 95 percent, of the volume of the gas should be passed upwardly through the descending coal in the conical member and out through the apertures 25 into the chamber 27, while the remaining volume of the gas will pass through the annulus directly into the chamber from the gasifier vessel. Normally, tars and oils will condense from the gases when the gases are cooled to temperatures of below about 200°C (400°F).

Gases flowing to the top of the conduit 23 exit tangentially to the conduit through exit conduit 29 which merges with a similar conduit 29' connected to the top of a second conduit 23 on the other side of the gasifier. The tangential exit gas conduits 29 and 29' combine to form a gas offtake conduit 31 which may be, in turn, connected to the conventional cyclone for secondary removal of fines or other particulate elements.

In alternative embodiments only one conduit 29 may be provided, or three or more corresponding conduits may be provided.

The change in direction of flow of the gases at the top of the conduit 23 and the circular or rotary motion imparted to the gases by the tangential exit gas conduits 29 and 29' will cause a primary separation of particulate matter from the gas stream, and such particulate matter will drop by gravity through the annular chamber 27 surrounding the conical member 17 back into the gasifier vessel 1 to be combined with the incoming coal.

The operation of the gasifier as described will produce a gas that will be cleaner and have less tar, oil, and particulate matter than gases produced in conventional fixed bed gasifiers. Cooling of the gases with the incoming coal will also reduce heavy tars and pitch present in the offtake gas caused by "cracking" volatiles with hot offtake gas, or eliminate such components completely. The use of the present invention will enable the use of fixed bed, single stage gasifiers operating in a "hot raw gas" mode in more applications than has heretofore been possible using conventional technology. The preferred embodiment of the present invention provides the benefits claimed for two stage gasifiers without the capital expense or coal selection restrictions inherent in such two stage gasifiers.

From the foregoing it will be appreciated that in a preferred embodiment of the invention the contact surface and duration of an incoming coal charge to a gasifier is increased (when ompared with prior art arrangements) without increasing the depth of the gasifier vessel. This results in the ability to operate the preferred gasification unit at high loads with less possibility of formation of blowholes or other weaknesses in the fire bed.

Also in the preferred embodiment the hot gases leaving the gasifier with the flow of incoming coal to the gasifier are cooled. Such cooling will result in the deposition of some tar and oil leaving the gasifier on the surface of the incoming coal, with a consequent reinjection of these tars and oils into the gasifier vessel. The preferred arrangement also has a fuel feed configuration which will allow for the use of swelling caking coals in the gasifier.

Additionally in the preferred embodiment a rotational motion is imported to the gases exhausted from the gasifier at a point where particulate matter separated by the change in flow of the gases and the rotational motion will return by gravity to the gasifier and be entrained in the incoming fuel stream.

Furthermore, in the preferred embodiment a gradual blending of gases exhausted from the gasifier is caused in a manner which will result in an exit gas from which tar and oil have been removed, but which will be heated to a temperature above the dew point of the exit gas so that deposition of remaining tar and oil in the distribution pipes is minimized.

CLAIMS

1. A fixed bed, solid carbonaceous fuel gasifier having a combustion chamber, a substatially vertically extending feed member extending from a solid fuel supply means to an inlet means for charging solid carbonaceous fuel to the upper portion of the gasifier,

through which solid fuel is charged by gravity to the gasifiers; a gaseous exhaust conduit, coaxial with and surrounding the feed member and spaced therefrom, the feed member having a plurality of apertures therethrough for the flow of gases therefrom into the exhaust conduit; the exhaust conduit having means adjacent the upper end thereof for the tangential removal of gases therefrom.

2. A gasifier according to claim 1 wherein the diameter of the feed member increases with increasing distance from the fuel supply means.

3. A gasifier as claimed in claim 1 or claim2 wherein said vertically extending feed member is in the shape of an inverted truncated cone.

4. A gasifier as claimed in claim 3 wherein said cone has an elliptical cross-section shape.

5. A gasifier as defined in claim 3 wherein said cone had a rectangular cross-sectional shape.

6. A gasifier as claimed in any one of the preceding claims wherein said vertically extending feed member terminates within the gasifier vessel and a baffle means is provided in the vessel dependent from the roof thereof spaced from and surrounding the lower end of said feed member.

7. A gasifier according to any one of the preceding claims wherein the space between the exhaust conduit and the feed member communicates with the combustion chamber.

8. A gasifier as claimed in any one of the preceding claims wherein a plurality of inlet means are present in the gasifier and wherein a substantially vertically extending feed member and gaseous exhaust conduit are provided for each of said inlet means.

9. A gasifier according to claim 8 wherein gases removed tangentially from the upper end of each exhaust conduit are combined and fed to a common exit gas conduit.

10. A method for producing combustible gases in a fixed bed, single stage coal gasifier, the method comprising: passing coal from a source thereof downwardly through a substantially vertically extending feed member positioned above the gasifier, said feed member having apertures therein, the feed member being contained within an exhaust gas conduit forming an annular chamber therewith, the exhaust gas conduit having a tangential exit gas conduit at the upper region thereof and charging the coal through an inlet into the combustion chamber; gasifying the coal to produce combustible gases; passing a portion of the hot gases directly from the gasifier into the annular chamber; passing the remainder of the hot gases from the gasifier upwardly through the descending coal in the feed tube to cool the same and condense tars and oils therein and discharging the cooled gases through the apertures in the feed tube into the chamber to combine with said hot gases; and tangentially discharging the combined hot and cooled gases from the upper region of the chamber into an exit conduit.

11. A method as claimed in claim 10 wherein the portion of hot gases passed directly from the gasifier into the annular chamber is suficient to maintain the temperature of the combined gases above the dew point of the gas.

12. A method as claimed in claim 11 wherein up to ten percent of the gases from the gasifier are passed directly from the gasifier into the annular chamber.

13. A method as claimed in any one of claims 10 to 12 wherein said feed member has a larger interior diameter at the lower end thereof than at the upper region thereof, sufficient to permit the passage of swelling and caking coals by gravity downwardly therethrough into the gasifier.

14. A method as claimed in any one of claims 10 to 13 wherein a plurality of said vertiacally extending feed members and exhaust gas conduits are provided and gases from the gasifier are passed therethrough and the gases are discharged from the upper regions of the annular chambers into exit conduits to be combined in a common gas offtake conduit.

15. A fixed bed solid carbonaceous fuel gasifier substantially as herein described with reference to and as shown in the accompanying drawings.

16. A method for producing combustible gases substantially as herein described with reference to the accompanying drawings.

17. Any novel feature or combination of features described herein.

Printed in the United Kingdom for
Her Majesty's Stationery Office, Dd 8818935, 1984, 4235.
Published at The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.